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Poster paper

Design concept for a modular in-vacuum Hall probe mapper for in-vacuum undulators and cryogenic permanent magnet undulators of varying magnetic length

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Both in-vacuum undulators (IVUs) and cryogenic permanent magnet undulators (CPMUs), each important to third-generation light sources, are best characterized in their operating environment. To create a precision Hall probe map of an IVU/CPMU (IVU hereafter), an in-vacuum magnetic measurement (IVMM) system is proposed. Point-by-point measurement of field and trajectory error informs corrective tuning.

A novel design concept for a universal IVMM System has been developed and explored. The IVMM seals to the rectangular Ultra High Vacuum (UHV) flange of the IVU and shares its common vacuum space. Moreover, a modular design permits a wide range of IVUs of varying magnetic length to be mapped with a single IVMM, and is thus cost effective when multiple IVUs of varying configurations are planned. Here we review aspects of the modular IVMM design concept.

1. Introduction

In-vacuum undulators (IVUs) designed to produce well-defined periodic magnetic fields act as high-brightness, tunable, narrow-band photon sources whose performance is dependent on field quality. To precisely characterize undulators, we must map their fields in the laboratory at operating conditions. Each functions at UHV pressure, the IVU at ambient temperature and the cryogenic permanent magnet undulators (CPMU) from 150 K (NdFeB) to as low as 40 K (PrFeB magnets). Fortunately, in the laboratory, these operating conditions can be closely simulated with rough insulating vacuum ($<10^{-4}$ Torr). The in-vacuum magnetic measurement (IVMM) design must be compatible with these environments while affording minimal thermal, electromagnetic and mechanical ‘crosstalk’.

Figure 1 shows the section view of the IVMM as viewed along the electron beam axis (Z). The Hall probe is retracted from the gap (or extended as shown phantom) in the lateral direction (X). To measure the mid-plane the probe moves

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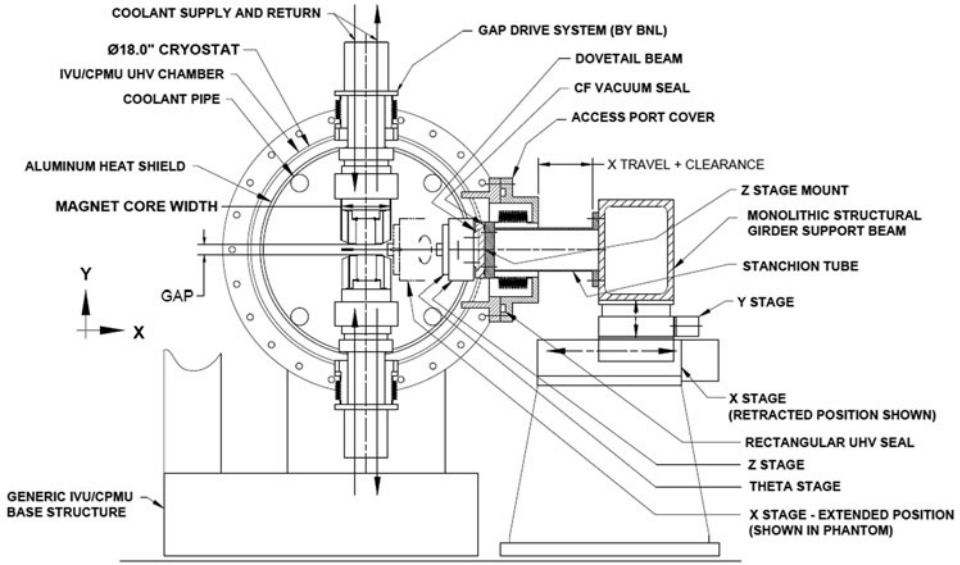


FIGURE 1. Cross-sectional view of the IVMM System.

vertically within the narrow limits of the gap opening (Y). To the stiff structural base of the IVMM mount two motorized stages, first X then Y , each outside of the vacuum containment. These stacked stages actuate a stiff monolithic beam having several cantilevered stanchions, each extending through the Insertion Device (ID) of a re-entrant bellows assembly. These circular bellows provide the mechanical feed-through for both degrees of freedom: displacement. The small Y -travel is afforded by bellows offset. The X -travel, which can exceed the pole width, is afforded by axial bellows.

Each stanchion joins the weld neck on a blank ConFlat © (CF) flange. The CF vacuum seal encircles an internal through-bolt pattern that mates to the fixed half of a dovetail assembly. The moveable companion half of the dovetail is in turn fixed to a long-travel linear stage aligned with the Z -axis. The Z -stage carries a rotary stage to invert the Hall probe to negate earth's field. To execute a survey at given (X, Y) coordinates redundant Z -passes with opposite probe orientations are averaged. The dovetails permit thermal contraction in Z of the long-travel stage. Figure 2 shows an anchored centremost stanchion to balance frictional load upon thermal contraction.

Deflections from the significant external pressure loading attributable to each bellows assembly, which is absent in true operation and therefore artificial to laboratory characterizations, may be negated by implementation of a pressure-compensating mechanical feed-through with design as depicted in figure 3.

Beam line and ring lattice demands commonly require IVUs of varying length. To accommodate these device lengths the IVMM utilizes a pair of 'end cans' with integral vacuum ports that receive those stanchions that fall outside the span of the rectangular UHV flange of the IVU. Those outer stanchions continue to provide support for the full fixed length Z -stage, while travel of the probe is kept symmetric about the midpoint and restricted to be equal to the IVU magnetic length. By sliding in increments equal to the span between stanchions, each 'end can' on its

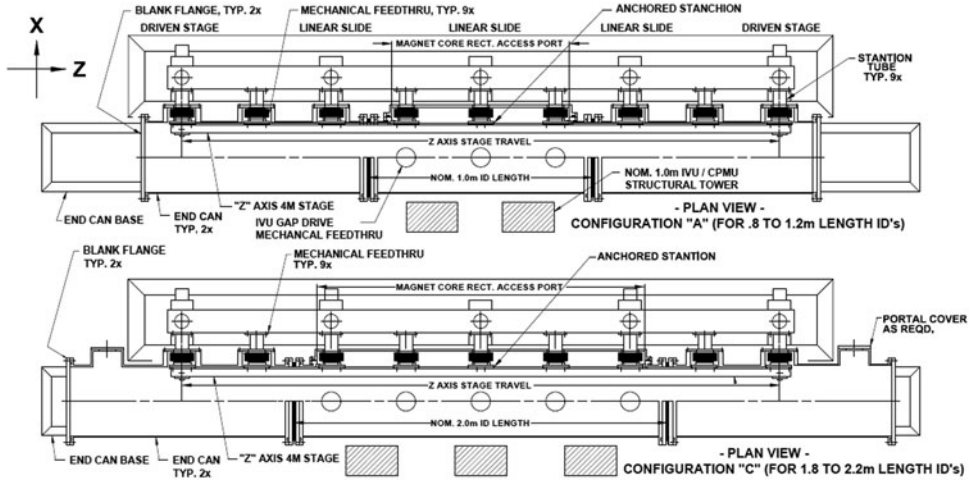


FIGURE 2. Incremental adaptation for IVUs of varying magnetic length.

Z-guide rail atop its stand, the IVMM can be reconfigured to accommodate progressively longer IVUs. Large interconnecting bellows at each interface between IVU and 'end can' afford adjustability so that a range of lengths is surveyed with each configuration.

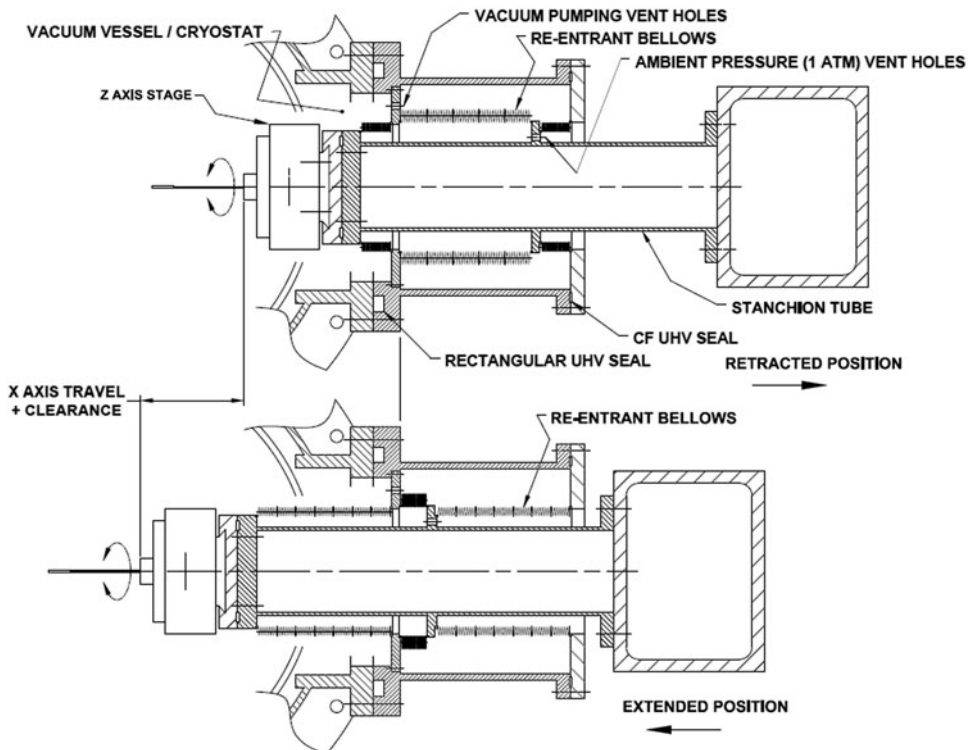


FIGURE 3. Pressure-compensating mechanical feed-through.

2. Conclusion

With proper foresight in design, an infinite (albeit discontinuous) range of source devices for a full synchrotron ring are characterized and optimized at true operating conditions using a single-precision IVMM system.

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